DIPHTHERIA.

ITS PREVENTION AND CONTROL.[1]

By J. W. SCHERESCHEWSKY, Assistant Surgeon General, United States Public Health Service. Revised by R. E. DYER, Passed Assistant Surgeon, United States Public Health Service.

Introduction.

Diphtheria is justly regarded as one of the most dreaded of the diseases of childhood. It has come down to us from antiquity under such names as "Egyptian sore throat," "Syrian ulcer," "malignant" or "putrid sore throat," "gangrenous ulcer," and the like, until its present name was given the disease by the great French physician Bretonneau in the first part of the nineteenth century. Membranous croup is another name for diphtheria.

Until the fruitful discoveries of Klebs, Loeffler, Behring, and others gave us the cause and the methods for the cure and control of diphtheria, few diseases had presented such high mortality, and there had been few before the march of which we were so helpless. An outbreak of diphtheria in a community caused a shudder of horror, for the old records are full of instances where all the children of a family were swept away in spite of all that the medical knowledge of that time could do.

Thanks, however, to our modern discoveries, there are few diseases about which we know as much as diphtheria. Its prevention and control are feasible, provided we have the intelligent cooperation of the sanitary authorities, the medical profession, and last but not least, the general public.

Before proceeding to discuss the cause, symptoms, control, and prevention of diphtheria, we ought to refer briefly to the "habits" of the disease, namely, its seasonal prevalence, where it is found, the ages at which it is most prevalent, and similar facts in relation to its spread.

Climate and season.—Diphtheria is a disease of temperate climates. It seems to be comparatively rare in the Tropics. So far as seasonal prevalence is concerned, while present the whole year round, it is decidedly more common in the colder months, June, July, and August showing the least number of cases. However, an epidemic once started may run its course uninfluenced by the season of the year.

Geographical distribution.—Formerly diphtheria seems to have been confined to more or less restricted regions. Its spread over the whole civilized world, however, has gone hand in hand with the development of modern transportation facilities. In cities in the Temperate Zone the disease is always more or less prevalent. In rural communities it is more likely to occur in epidemics.

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Age and diphtheria.—Statistics tell us that the deaths from diphtheria occur chiefly among children less than 5 years old. In general, there are two factors operating to produce this result, namely, the fact that natural immunity to diphtheria is more rare during the early years of life, and the tendency of diphtheria to involve the larynx and windpipe in young children. The accompanying chart (Chart No. 1), based on studies made by the New York City Department of Health, shows the increase in susceptibility to diphtheria during the first two years of life and the development of immunity thereafter.

The mortality statistics of the United States Census Bureau show that in the year 1919 about 56 per cent of all deaths from diphtheria in the registration area for deaths occurred in children under 5 years of age.

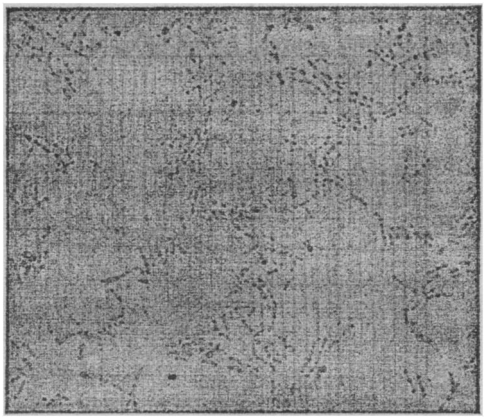


FIG. 1.—Diphtheria germs stained and highly magnified.

The Cause of Diphtheria.

The diphtheria germ.—Diphtheria is caused by the growth, usually in the throat, nose, or windpipe, of a germ known as the diphtheria bacillus or Klebs-Loeffler bacillus, discovered by Klebs and first studied by Loeffler. The appearance of this germ, magnified many times by the microscope, is shown in the accompanying cut.

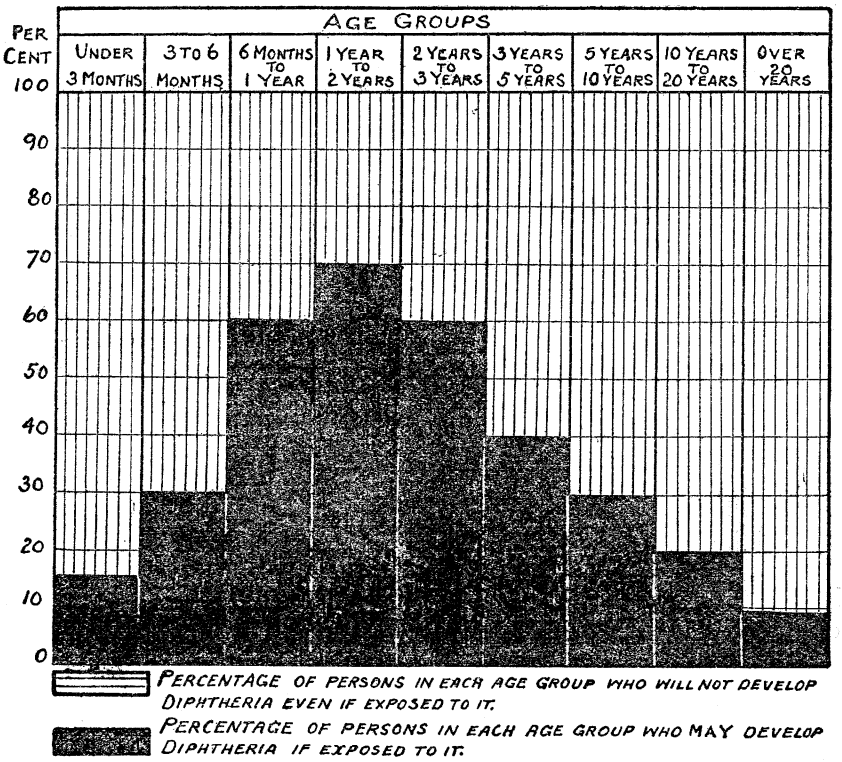
The form of this germ is quite distinctive, so that trained observers have little difficulty in distinguishing diphtheria germs from the ordinary germs found in the throat.

The diphtheria germ is constantly found, in all persons suffering from diphtheria, at the spot where the disease process is going on, and also, occasionally, in the throats of healthy persons, to whom, apparently, it may do no damage, but who, nevertheless, are capable of giving the disease to others. These are the so-called "diphtheria bacillus carriers," to be considered more fully later.

The presence of the diphtheria germ in the affected part causes the formation of a greyish membrane. The germ multiplies in the membrane and at the same time throws off a powerful poison or "toxin," which can cause death when absorbed by the body in sufficient quantities, and which is the chief cause of the symptoms of the disease.

How the presence of the diphtheria germ is detected in cases of diphtheria.—Most of our knowledge of the form and properties of the various germs arises from the fact that, aside from finding them in the bodies of the sick, they may be grown artificially, in the laboratory, on various substances given the general name of "culture media." These media are broths and jellies of various compositions, often especially adapted to the needs of the germs it is desired to grow. As a result of a great deal of experimenting, a culture medium has been found upon which the diphtheria germ outgrows the other

CHART No. 1.—Showing the early increase in susceptibility to diphtheria, followed by the development of a natural immunity.



ordinary germs which are always present in the throat, mouth, and nose. If, then, we suspect that a person is suffering from diphtheria, a sterilized cotton swab is rubbed over whatever spot seems to be affected and then passed gently over the surface of the proper culture medium for the diphtheria bacillus contained in a test tube. If the diphtheria germs are present some will cling to the swab and some of these are rubbed off onto the surface of the culture medium.

The tube is then kept in a warm place, such as in an incubator maintained at body heat, for 8 to 12 hours, at the end of which time

a growth of the diphtheria germs will appear on the surface of the culture medium. A particle of the growth is taken, rubbed up with a little water on a glass slide, dried, stained with an analine color, and examined under a microscope. The expert can often, however, make a diagnosis by examining microscopically some of the material rubbed directly from the swab onto a glass slide and stained. Most cities maintain laboratories where physicians can have examined the cultures which are taken from persons suspected of having diphtheria, and many State boards of health maintain similar laboratories where cultures may be sent from communities in which no laboratory is located.

Vitality of the diphtheria germ.—Fortunately for us, the diphtheria germ is rather frail. It is easily killed by ordinary disinfectant solutions, such as 1: 1,000 solution of bichloride of mercury (two 7½-grain tablets to a quart of water) or 2 per cent solution (5 teaspoonfuls to the quart of water) of phenol (carbolic acid). Under ordinary circumstances the germ is rather easily killed by drying; but when it is contained in pieces of membrane, such as are frequently coughed up in the course of diphtheria, it may live for some time. (Instances are on record of the germs preserving their vitality for months when such pieces of membrane remained in damp and dark basements or cellars.) It has also been found that diphtheria germs, dried on such objects as a child's building blocks, may remain alive for several months. Heat quickly destroys the diphtheria germ, but temperatures as low as freezing are not fatal to it.

How diphtheria is "caught."—Each new case of diphtheria is derived from a previous case or from a "diphtheria bacillus carrier" (i. e., an apparently well person who harbors the diphtheria germ in his nose, throat, or mouth). The spread of the disease from infected persons to relatives, friends, schoolmates, attendants, or to other persons who come in close contact as in crowds, street cars, and theaters, may take place by direct contact, as by kissing, or through sneezing or coughing. In sneezing and coughing, minute droplets are thrown out a distance of several feet. These droplets contain germs that were in the mouth, nose, or throat, and are carried along by the force of the cough. These germ-laden droplets may lodge in the mouths of others or be breathed in with the inspired air or, having lodged on the hands, may be carried to the mouth in eating. Indirectly the germs may be transferred through the agency of various objects such as pencils, apples, candy, eating utensils, drinking cups, and the like, which have been placed in the mouth or sprayed with the nose, mouth, or throat discharges of persons infected with the diphtheria germ.

The underlying principle which governs the transmission of the disease is the freedom with which exchanges of the mouth and throat fluids take place between human beings. A very little watching is enough to convince us of the many times during the day that the hands are carried to the mouth and then used to handle objects in common use. The greater tendency in children to place objects in the mouth and the closer contact of children with each other and with adults is perhaps one reason why children take diphtheria more frequently.

With the exception of the part played by milk in the spread of the disease, to which reference is made later, modes of infection other than those already mentioned are unimportant. The old belief that diphtheria can be spread through sewer gas, polluted soil, rotting refuse, or through the air, is unsupported.

Diphtheria "bacillus carriers."—By the term "bacillus carrier," we mean a seemingly well person who harbors bacilli or germs of a disease in his body. Such a person, or "carrier," may infect others with the germ of some communicable disease, such as diphtheria, typhoid fever, cholera, cerebrospinal meningitis, and the like.

It was early noticed that the germs of diphtheria might be found in the nose, mouth, or throats of apparently healthy persons and, furthermore, that such germs might be virulent, i. e., capable of giving the disease to others. Persons who have been in contact with those suffering from diphtheria are especially likely to be "carriers;" yet a certain percentage of the population of any community will be found harboring the diphtheria germs, although unaware of having been exposed to any case of diphtheria. This percentage of the population varies, being greater when there is much diphtheria in the community. The diphtheria germs found on the examination of "carriers" vary in "virulence," or ability to cause the disease. The majority of the diphtheria germs harbored by well persons, although indistinguishable by the microscope from the germs taken from diphtheria cases, are not virulent; that is, do not have the power or strength to cause symptoms of diphtheria. A certain percentage of "carriers," however, harbor virulent diphtheria germs, but do not develop symptoms of diphtheria on account of their natural immunity or resistance to the diphtheria germ.

When diphtheria is only ordinarily prevalent in a community, probably from 1 to 2 per cent of the population will be found to be carriers of the germ, and of these carriers only about 1 in 10 harbors virulent diphtheria bacilli. In time of epidemics, however, and especially among the inmates of institutions where there are outbreaks, the proportion of "carriers" may be greatly increased.

There seems to be a relation between the frequency with which the diphtheria germ is found in the throats of persons in whose house there is a case of diphtheria and the care taken in isolation of the

sick. When care has been taken in isolation about 10 per cent of the other members of the household have been found to be "carriers." In families where they have been careless in the matter of isolation the number of "carriers" has been found to be much higher.

Milk-borne diphtheria.—The germ of diphtheria grows freely in milk, and as this food undergoes so much handling during production the germs of diphtheria must often have an opportunity to get into milk unless due care is taken. Widespread outbreaks of diphtheria have occurred in which the finding of diphtheria germs in the milk has proved that this food was acting as the vehicle of transmission for the infection. The germs get into the milk at the farm or the dairy or through careless handling by the distributors, either because of the presence of a case of diphtheria or because some person concerned with the production of the milk has been a diphtheria "carrier."

The Symptoms of Diphtheria.

Period of incubation and duration.—The period of incubation of diphtheria, i. e., the time which elapses between receiving the infection and the appearance of the first symptoms of the disease is short, being from 2 to 7 days in cases in which this has been traced. The duration of the disease is variable, being from a few days to weeks or even months, especially in cases of nasal diphtheria. On the other hand, the disease may be so severe from the outset that death occurs within 24 hours.

Local symptoms.—The symptoms of diphtheria may best be understood by keeping in mind the fact that it is a disease showing local manifestations on the mucous membranes, usually of the respiratory tract (nose, mouth, throat, windpipe, and even lungs), and general symptoms of sickness caused by the absorption by the body of the poison that is produced by the diphtheria germs. The local manifestations occur at the site where the germs have gained a foothold and are multiplying in great numbers. Most frequently this occurs on the tonsils and back of the throat, but may occur in the nose alone or in the windpipe or in the larynx (beginning of the windpipe). Where the germs are at work, there is formed a "membrane" which is usually grayish white in color. In diphtheria of the throat the child may complain of difficulty in swallowing even before the membrane begins to form. If the throat is examined at the time, it will be seen to be reddened, and the tonsils will probably show some swelling. Within a short time the membrane begins to form, usually on the tonsils. It will appear as a grayish white patch, which will increase in size with varying degrees of rapidity. Several patches may be noticed at first which later grow together, or a single patch of membrane may spread till it covers both tonsils, the soft palate, and the back of the throat. The neck becomes swollen and tender,

and lumps may be felt on the outside. These lumps are swollen lymph glands. Swallowing may become almost impossible. As long as the membrane is confined to the visible parts there is usually little difficulty in breathing. When extension of the membrane downward into the larynx occurs, there is a huskiness or hoarseness of the voice which may increase until the voice is lost altogether. Difficulty in breathing sets in, caused by the mechanical blocking of the air passages by the membrane and by the swelling of the parts affected. Breathing becomes more and more difficult, and there is blueness of the finger nails and of the lips. Later the face may become dusky as the supply of air is gradually cut off. Death may occur from suffocation or from action of the diphtheria poison which has been absorbed.

General symptoms.—The general symptoms of diphtheria are caused chiefly by the absorption of the poison which is produced by the diphtheria germs, and usually vary in severity with the severity of the local manifestations described above. The onset may be gradual, with slight indisposition for a day or two and with a moderate degree of fever. In other cases the disease may begin abruptly with headache, prostration, high fever, and rapid pulse. After the disease is well established, there is marked prostration and muscular weakness, the surface of the body may be covered with a cold perspiration, the pulse is rapid and feeble and, at times, irregular. There may be dullness and apathy but, usually, on account of the discomfort of the local symptoms and the difficulty in breathing, there is great restlessness and excitement. The systemic poisoning may be so severe as to cause death before difficulty in breathing has become marked. Heart failure from the action of the poison on the heart may occur early or late in the disease or even after convalescence has begun.

Varying degrees of severity are seen in diphtheria cases, from mild cases in which only a small amount of membrane is formed and the general symptoms are so mild that it is difficult to keep the child in bed, to cases so severe that death occurs within 24 to 48 hours of the onset of symptoms. Fortunately such severe cases are rare.

Other sites of diphtheria infection.—While the usual seat of the diphtheritic process is the mucous membrane of the throat, such is not always the case. The infection may have its starting point in other places, as, for instance, the nose, within which a thick diphtheritic membrane may be developed. Nasal diphtheria is justly dreaded, not only because of the fatality in acute cases, but because the disease in this situation tends to become chronic. As the symptoms of nasal diphtheria may, at first, be only those of an ordinary "cold" in the nose, and because it is much more difficult to see into the nose than into the throat, the disease under such circumstances may readily escape detection. For this reason, if

for no other, the taking of nasal swabs for culturing should be as much a matter of routine in the diagnosis of suspected cases as the taking of swabs from the throat.

Diphtheria may also begin in the larynx and windpipe, instead of the throat, thus giving rise to laryngeal diphtheria or "membranous croup," the most serious of all forms of the disease. As already pointed out, extension of the membrane from the throat into the windpipe during the course of the disease is also a frequent and dangerous complication of throat diphtheria. The membrane may even extend down into the lungs and cause pneumonia.

Besides the nose, throat, and windpipe, diphtheria infection can spread from the throat to the mouth, so that even the lips become involved, or the ear may become infected through the canal (the Eustachian tube) by which it opens into the throat. The delicate lining membrane of the eyelid or conjunctiva may become infected, causing diphtheritic conjunctivitis. Instances have been observed of the growth of the membrane in the intestines. Wounded surfaces, too, may become involved, giving rise to wound diphtheria.

Diphtheritic paralysis.—A common complication of diphtheria is the paralysis of one or more groups of muscles which takes place either in the course of the disease or during convalescence, even from mild attacks. The muscles chiefly affected are those of the palate, the throat, and the eye. Other muscles, however, may also suffer.

Heart failure may occur during the height of the disease or even a considerable time after the local symptoms have disappeared and the patient is considered well enough to be out of danger. Failure of the heart may be the result of paralysis of the nerves of the heart or changes caused in the heart muscle by the diphtheria poison.

The Treatment of Diphtheria.

The poison or "toxin".—A few words as to the poison generated by the diphtheria germ will aid in understanding the treatment of the disease. The germs themselves multiply chiefly at the site of membrane formation which, as a rule, is in the throat, windpipe, or all three in extensive diphtheritic infections. The poison they produce, however, is readily absorbed or taken up by the body and penetrates the system. The poison seems to be especially injurious to the heart, blood vessels, nerves, and kidneys. It is due to the action of the poison that we get the somolence, listlessness, small and rapid pulse, the ashy color of the face, the restlessness, the inflammation of the kidneys, the paralyses, and the ominous symptoms of bleeding from the nose or from the diphtheritic membrane, and the discoloration of the skin in the course of diphtheria.

The poison of diphtheria is no imaginary product invented to account for the symptoms caused by the disease. It can be readily manufactured in the laboratory from diphtheria germs and is so powerful that extremely small amounts injected under the skin will produce death in animals.

Diphtheria antitoxin.—Scientific medicine achieved one of its greatest triumphs when it placed in our hands the specific remedy for diphtheria—diphtheria antitoxin. Were it possible to apply this remedy in sufficient dose and early enough in all cases, the mortality from diphtheria would almost vanish. As it is, the disease has been robbed of much of its former terror.

It has been found that animals injected with slowly increasing doses of diphtheria poison, or "toxin" (which as has already been stated can be readily made in the laboratory), gradually became immune to its effects, so that they stand without harm what would be a many times fatal dose when first the injections are begun. This ability to withstand the poison is due to an antidote or antitoxin manufactured by the animal's body. This antitoxin combines with the injected toxin and renders the latter powerless. The antitoxin is produced in such large quantities that the blood is full of it and this blood retains its antitoxic properties, even though drawn from the immunized animal and injected into another animal. In practice we take the blood of an animal that has been immunized by repeated doses of diphtheria toxin, allow it to clot, and draw off the clear serum in which the clot floats. This serum contains antitoxin and, if injected into a human being, this antitoxin will combine with any diphtheria toxin that may be present and neutralize it, thus protecting the individual.

Manufacture of diphtheria antitoxin.—Diphtheria antitoxin is made commercially from the blood serum of horses, because the horse reacts to the poison when injected by producing a very large amount of antitoxin in its blood, and can be bled in large amounts without permanent injury. Only perfectly healthy horses, shown to be free from tuberculosis and glanders, and protected by tetanus antitoxin against lockjaw, are used in its manufacture. All establishments for the manufacture of vaccines, antitoxins, and similar products used in interstate commerce are licensed, their laboratories inspected, and their products tested for purity by the United States Public Health Service, so that the general public can be assured of the purity of their output. Diphtheria antitoxins are tested for potency as well.

Potency of antitoxin.—The curative power of diphtheria antitoxin, or its "potency," is measured in "antitoxin units." The antitoxin unit involves a number of theoretical considerations and is difficult to define briefly. Essentially, however, it is the power of a certain

amount of a standard diphtheria antitoxin to neutralize diphtheria toxin. The United States Public Health Service furnishes this standard antitoxin with which all other diphtheria antitoxins manufactured in the United States and used in interstate commerce are compared. A strong diphtheria antitoxin should contain from 800 to 1,200 of these units to each cubic centimeter (1 cubic centimeter is equal to approximately 15 drops).

Results of the use of antitoxin.—For each of the seven years prior to the introduction of antitoxin (1887 to 1893), the number of deaths from diphtheria in each 10,000 population unit in New York City was 14.5, whereas in the five years after the use of antitoxin became general, the number of deaths occurring yearly among each 10,000 people dropped to 6.3. In the year 1920 the diphtheria death rate per 10,000 population in the registration area of the United States had dropped to 1.53. Furthermore, prior to the use of antitoxin, 35 to 45 per cent of diphtheria cases died, whereas at the present time (1921) this fatality rate has dropped to about 9 per cent. That the fatality is not still further reduced is due to the fact that not every case of diphtheria receives the antitoxin treatment, or that it is not employed soon enough, or that the dose has been insufficient.

Influence of antitoxin on the local symptoms of diphtheria.—The most marked influence of the antitoxin treatment of diphtheria upon the local symptoms of the disease consists in hindering the spread and causing the rapid disappearance of the membrane. If the dose of antitoxin has been given in time and in sufficient quantity, the membrane begins to loosen usually within 24 hours from the time of injection. The action of antitoxin in preventing the spread of the membrane is of the greatest importance, especially in those cases in which there is a tendency for the membrane to spread to the windpipe, or, when the windpipe is already affected, to extend downward toward the lungs.

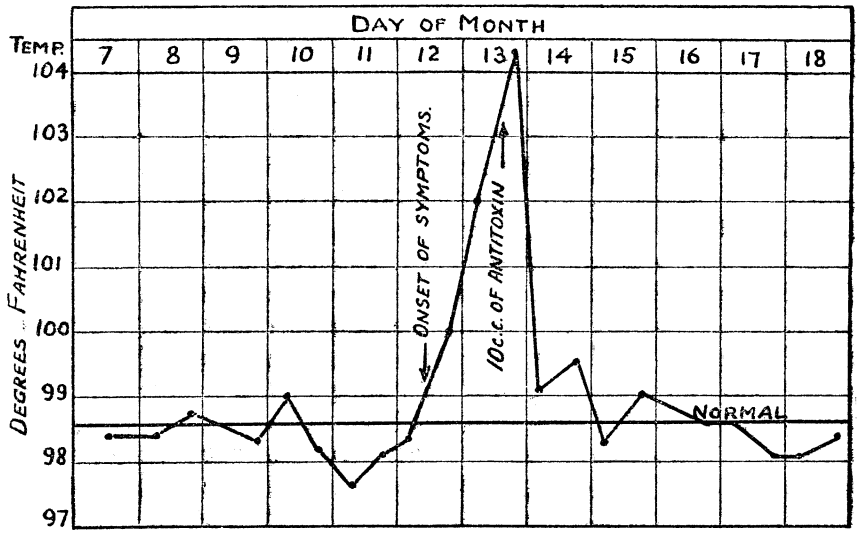
Effects of antitoxin upon the general symptoms of diphtheria.—With an improvement in the local symptoms, there goes hand in hand betterment of the general symptoms. The swelling of the glands of the neck diminishes, the fever drops, the appetite commences to return, the patient feels better in every way. Chart No. 2 shows the striking effect of a dose of antitoxin on the fever in diphtheria.

Limitations of antitoxin.—The success of the antitoxin treatment of diphtheria depends on the neutralization of the diphtheria poison by the antitoxin before the poison has opportunity to injure the body cells. Once the poison has injured the cells of any part of the body, as the heart, nerves, or kidneys, the antitoxin is powerless to repair that injury. This fact will explain in large measure the failure of antitoxin given late in the course of the disease to prevent paralysis

or death. The element of time and the amount of poison which has been taken up by the body are important considerations. The larger the dose of poison present in the system, the less time there is to lose if we are to save the patient. Fortunately, the appearance of the first symptoms of poisoning does not necessarily indicate that a fatal dose has been absorbed, so that, even in apparently desperate cases the patient may get well if antitoxin in sufficient amount be given.

Importance of the early use of antitoxin.—We learn from the foregoing the important fact that antitoxin must be given as early as

CHART No.2.—Showing the effect of an injection of antitoxin early in a case of diphtheria.



Typical effect of an injection of antitoxin at the outset of a case of diphtheria. (After Kolle and Hetsch.)

possible in the course of the disease. The accompanying chart shows the striking differences in the fatality from diphtheria accordingly as antitoxin is administered early or late in the disease.

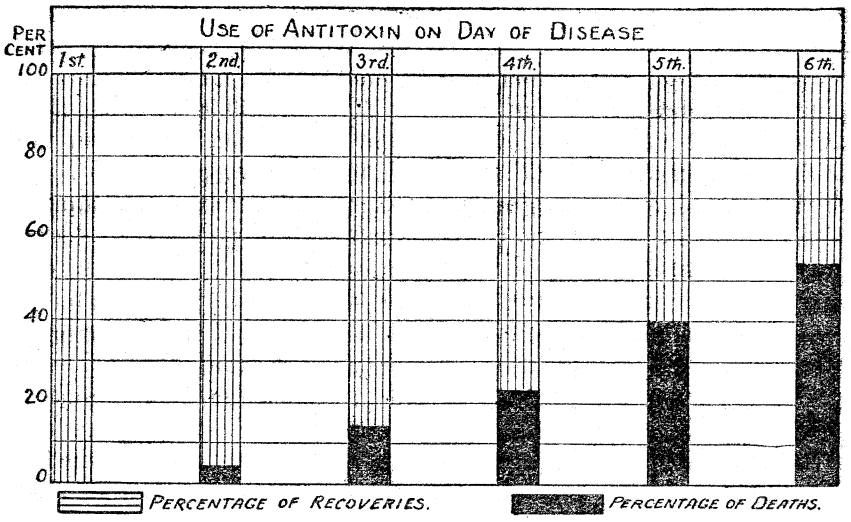
An examination of Chart No. 3 shows, in the large series of cases upon which it is based, that when antitoxin could be given on the first day of the disease there were no deaths. When the administration was delayed to the second day after about 5 per cent died. Administration on third, fourth, fifth, and sixth days showed the progressively increased fatality of 12.5 per cent, 22 per cent, 39 per cent, and 50 per cent, respectively.

We also find a relation between the early use of antitoxin and the frequency with which the crippling paralyses, so frequent in diphtheria, occur. The earlier the use of antitoxin, the less likelihood

there is of the subsequent development of paralysis. The overwhelming importance of the time element in the antitoxin treatment for diphtheria can not be too strongly emphasized. A few hours lost in beginning treatment may mean all the difference between life on the one hand and death or crippling on the other. When the general public realizes that in the treatment of diphtheria no time is so precious as that lost at the outset, and that the energetic, early use of antitoxin creates mastery of the situation, many valuable lives will be saved which are now wasted by timidity and procrastination.

Methods of use and dose of antitoxin.—While the administration of the antitoxin treatment of diphtheria is necessarily in the hands of

CHART No. 3.—Showing how the chances of recovery from diphtheria are increased by the early use of antitoxin.



Curative action of antitoxin on different days of the disease. (After Kolle and Hetsch.)

the attending physician, a few remarks as to its use and the proper dose will not be out of place.

Antitoxin is placed on the market by the manufacturers in sterile containers, usually in syringes, ready for use, with the potency in antitoxin units per cubic centimeter plainly stated on the label.

There are three methods of administering antitoxin—by injecting the remedy directly under the skin, into the muscles, or into a vein. Whatever method is used, the skin over the site chosen for the injection is first cleansed with care and disinfected. The choice of method to be used depends largely upon the needs of the case. When injection is made into the muscles, absorption takes place in about one-third of the time required when the injection is made directly under the skin. If given into a vein, the antitoxin is immediately available

for use in neutralizing the poison already absorbed. Since time is all important in the treatment of diphtheria, it follows that injection directly under the skin should be used only when giving the treatment early in the course of mild cases. Choice between injecting into the muscles or into a vein depends upon the severity of the disease and the time that has passed since the first symptoms appeared. In general it may be stated that severe cases seen after symptoms of poisoning have appeared should receive the antitoxin by injection into a vein.

In selecting the dose to be given in any case we must be guided by the time that has elapsed since the onset of the disease, the age of the patient, the severity of the case, and the method of administration. Children require less antitoxin than adults, mild cases less than severe ones, and early cases less than those seen late. More antitoxin is required when the remedy is given under the skin than when given into the muscles or veins. Three thousand units may prove sufficient for the treatment of an early mild case in a child, whereas a severe case in an adult would require 50,000 units. It is probable that at least 10,000 units should be given in all save the mild cases seen soon after the first symptoms have appeared. Sufficient antitoxin should be given at the first dose, as time lost through failure to do so can not be entirely retrieved by giving later doses. It is important to remember that the liberal use of antitoxin is our only means for preventing the extension of diphtheria in the body.

All cases showing by huskiness or a whispering voice that the windpipe is involved by extension of the membrane should be regarded as severe cases without regard to the severity of the general symptoms. If, from the facts in the case, it is apparent that the patient has been sick for more than three days, we must regard his life as having already been endangered. While severe poisoning may result with only trifling local symptoms, the state of the affected parts is a fairly good index of the amount of poisoning likely to ensue. A rapidly spreading membrane, fetid breath, great swelling of the glands of the neck, a blood-stained discharge from the mouth and nose are signs that the case is severe and dangerous, and symptoms of poisoning are to be expected unless averted by a big dose of antitoxin. The presence of kidney involvement, somnolence, listlessness, a fretful, peevish voice, a small rapid or irregular pulse are to be regarded as symptoms of poisoning.

Harmful effects of antitoxin.—Following the administration of antitoxin a number of disagreeable symptoms sometimes develop. These symptoms are manifestations of "serum sickness" and may last some 8 or 10 days. This sickness comes on from two days to two weeks after the injection of antitoxin and is due not to the antitoxin itself, but to the fact that the serum containing the antitoxin is from another

class of living beings, viz, the horse. There is slight reddening of the site of injection and swelling of the neighboring lymphatic glands. The next symptom is an eruption, most intense at the spot where the antitoxin was injected and the surrounding skin, which belongs to the group of nettle rashes. The eruption soon spreads over the whole body and may be very itchy. The eruption may resemble measles or scarlet fever. On the other hand, the eruption may be scanty or transient. Some fever is usually present. In addition to the above there are often localized swellings of the skin, knuckles, or conjunctiva. More infrequently there are pains in the joints which may give great discomfort and difficulty in handling the patient. Recovery always ensues.

Hypersensitiveness.—Occasionally individuals are found in whom the injection of antitoxin is followed by severe collapse and even death. This is not due to the antitoxin, but is because horse serum is poisonous to a very small number of individuals. Fortunately, such persons are very rare. About one death has occurred to each fifty or seventy-five thousand persons injected. The tendency to be poisoned by horse serums seems peculiarly marked in persons who suffer from bronchial affections and asthma. Some individuals are so sensitive that they can not work in the vicinity of horses without being subject to asthmatic attacks.

When it is necessary to give antitoxin to persons subject to asthma, it is better to give it in divided doses. One-tenth of a cubic centimeter every 15 or 20 minutes can usually be given with safety.

The Care of Diphtheria Patients.

Home care.—Proper care of the diphtheria patient is important in the control and prevention of diphtheria. It is here that the private citizen, if he does his full duty, becomes an efficient unit in the campaign against preventable disease. The communicability of diphtheria and the fact that "carriers" of the germ result from contact with persons sick of the disease, render imperative the strict isolation of diphtheria patients.

The sick room.—The first rule in the care of diphtheria in the home is to place the patient in a separate room. This room should, if practicable, be on the floor of the house the least in use, though its adaptability as a sick room should be taken into account. All unnecessary furniture should be removed. What furniture is left should be of a kind which may be readily cleansed.

There is no need for fancied attempts at purifying the air by means of hanging sheets wet with disinfectants and the like. If possible, the mattress should be completely covered with a rubber sheet which can be washed from time to time with a disinfectant solution.

Separate linen, bedclothing, etc.—Separate towels, bed clothing, nightgowns, eating utensils, and drinking vessels should be provided for the patient's exclusive use. These should always be kept free from contact with those used by the rest of the family. After being used by the patient, they are to be placed in one of the disinfectant solutions given below or boiled in water.

Attendant for the patient.—The patient should be provided with an attendant who remains with the patient and holds no communication with the other members of the family. This attendant should be the only person caring for the patient or coming in contact with him apart from the attending physician.

Use of disinfectants.—A tub of good disinfectant solution should be at hand for soaking articles which have been used by the patient. A basin of disinfectant should also be provided for cleansing the hands of the attendant. Proper disinfectant solutions are:

(*a*) Two per cent solution of phenol (carbolic acid).

(*b*) Two per cent solution of liquor cresolis compositus U. S. P. (compound solution of cresol).

A 2 per cent solution is made by adding 3 ounces (6 tablespoonfuls) of the disinfectant to 1 gallon of water.

All surfaces soiled by discharges from diphtheria patients should be mopped or flooded with the disinfectant solution.

All articles used by the patient should be soaked for two or more hours in one of the disinfectant solutions or thoroughly boiled. Discharges from the nose and throat of the patient are to be received into pieces of cotton gauze, or old, clean squares of cloth, which are then placed immediately after use into the solution of disinfectant or burned. Partially eaten food is also disposed of by burning.

Care of the attendant's hands.—It is important to remember that the hands are extremely likely to become infected with diphtheria germs when caring for diphtheria patients and that these germs may then be carried to the mouth. Unnecessary handling of the patient should therefore be avoided. Whenever handling is necessary, the hands should be immediately cleansed in disinfectant solution and then washed with soap and water. This precaution must always be taken by the attendant before eating.

Other precautions for the attendant.—A loose gown or a wrapper should be provided to protect the attendant's clothing. This covering should always be regarded as infected and not sent out of the room until it has been soaked in disinfectant. In the case of female attendants, the hair should be completely covered by a cloth or hood when engaged in caring for the patient. The patient may cough violently in the attendant's face, thus spraying the attendant with the mouth and throat discharges and, possibly, bits of membrane. If this happens the face should be washed at once in disinfectant

solution, including the hair if it has been left uncovered. If the hair has been covered, the covering should be placed in the disinfectant solution.

Gowns and head coverings should also be provided for the attending physician. These are kept outside of the room and are soaked in the disinfectant after being used.

Gowns, headdresses, and the like may be thoroughly boiled in water or soapsuds instead of being soaked in a disinfectant solution.

Cleansing the room.—The room should be thoroughly aired two to three times a day. In cold weather the patient should be protected from draft at such times. No sweeping should be done, but the floor and furniture should be wiped with cloths dampened in disinfectant solution. After use the cloths should be soaked in disinfectant or boiled.

Bath after recovery.—After recovery the patient's entire body, including the hair, should be bathed. The patient should then be removed from the sick room and dressed in clean clothes which have not been in the room during the sickness.

Subsequent treatment of the room.—The subsequent cleansing and disinfection of the room after the patient's recovery will, in cities, be covered by the regulations of the local board of health. When the householder must follow his own initiative in this matter, the following measures should be carried out:

The room should be thrown open freely to air and sunshine. All bed linen, towels, nightgowns, and the like are to be disinfected either by soaking in a disinfectant or by boiling in water. Books and toys used by the patient should be burned. The floors, woodwork, and furniture should be wiped with cloths soaked in disinfectant. Mattresses are best disinfected with steam; otherwise they should be burned. If, however, they have been thoroughly protected by a rubber sheet, after removal of the latter they may be sunned on both sides for a number of successive days.

Duration of isolation in diphtheria.—Persons suffering from diphtheria should be isolated until cultures taken from the throat and nose on at least two successive occasions fail to show the presence of diphtheria germs or until the germs present are shown to be "avirulent" (not able to cause the disease).

Reporting the case.—The efficient control of diphtheria depends upon exact knowledge of its prevalence. It is therefore the public duty of all citizens to report cases of diphtheria to the sanitary authorities and to have the houses in which such cases exist placarded.

It is similarly the duty of the householder scrupulously to observe all regulations made by the local health department with respect to the quarantine of diphtheria cases. All cases of sore throat, especially if occurring in more than one member of a family, should be isolated

and steps should be taken to have nose and throat cultures sent to health office for examination.

Protection of food supplies.—When a household in which there is a case of diphtheria is engaged in any occupation having to do with the handling of food, such as the grocery business, dairying, and the like, such occupation should be discontinued until recovery of the patient from diphtheria and virulent diphtheria germs are found to be absent from the recovered case and from the nose and throat of each member of the family. Should the patient be removed to a hospital for contagious diseases, business may be resumed when it is shown that none of the other members of the family is harboring virulent diphtheria germs, and the necessary cleansing and disinfecting of the premises have been done.

Hospitalization.—From the foregoing discussion of the care necessary for the proper treatment of diphtheria in the home and the precautions required to prevent the spread to other members of the same family, it is quite evident that not all homes are equipped to give this care or render possible the exercise of the proper precautions. Could all cases of diphtheria be promptly hospitalized upon occurrence, we could expect a definite decrease in the percentage of diphtheria cases which end fatally. Furthermore, investigations of diphtheria have definitely shown that the removal of cases of diphtheria to isolation hospitals has a marked effect in reducing the occurrence of other cases in the same family. With the exception of those homes where excellent isolation can be carried out under the care of a trained attendant, hospital treatment is to be recommended. The decision as to hospitalization must be left in the hands of the local sanitary authorities.

Immunity to Diphtheria.

Immunity to diphtheria, or the ability to resist infection with the diphtheria germs even though exposed to them, is divided into two classes—natural immunity and acquired immunity.

Natural immunity.—By referring to Chart No. 1 it will be seen that a certain number of persons in each age group have a natural resistance or immunity to diphtheria. These persons are immune because they have in their bodies enough antitoxin to prevent the development of symptoms of diphtheria even if exposed to infection. Such immune persons may harbor the germs of diphtheria on the mucous membrane of the nose or throat and by so doing act as "carriers" although they will not develop the disease themselves.

Acquired immunity.—By injecting diphtheria antitoxin under the skin, the individual receiving the injection is rendered immune to diphtheria for as long a time as the antitoxin remains in the body. This varies from two to four weeks. However, if at the same time

the antitoxin is injected, a small amount of diphtheria toxin or poison is also injected, the resulting immunity will be of slower onset but of much longer duration, probably lasting throughout the age of susceptibility and possibly for life. When the antitoxin and poison or toxin are given together the mixture is spoken of as toxin-antitoxin.

Unlike some of the other contagious diseases, such as measles and smallpox, one attack of diphtheria does not protect the individual against a second or even third attack, in all instances.

Determination of immunity.—By use of a test known as the Shick test, so called after the man who discovered it, it is possible to determine what individuals possess immunity to diphtheria, and likewise those who are likely to catch the disease if exposed to it. This test is carried out by injecting a very small amount of diphtheria toxin into the skin of the forearm. If there is no antitoxin in the blood, the skin around the site of injection becomes reddened in a few days, showing that the individual being tested is not immune to diphtheria. This person may then be rendered immune by injecting a mixture of toxin and antitoxin as mentioned in the preceding paragraph.

The Prevention of Diphtheria.

Diagnosis of cases.—We readily understand from the foregoing that the correct diagnosis of diphtheria plays a very important part in its control. Not only does the safety of the community depend upon the detection and isolation of cases of diphtheria, but the early recognition of the disease diminishes the mortality because treatment is also earlier. It may be well to emphasize at this point that the taking of cultures from the nose is quite as important in the detection of cases and "carriers" as the taking of throat cultures. Both should invariably be taken.

As 24 hours of valuable time must elapse before the laboratory diagnosis can be surely made, in time of diphtheria prevalence suspected cases of diphtheria should be given the antitoxin without waiting for bacteriological diagnosis. This is especially true in the treatment of young children. The antitoxin should be given and nose and throat cultures taken at the same time. If the result of examination is negative, no harm has been done, whereas if the illness is diphtheria, just so much time has been gained and possibly a life has been saved. Much could be accomplished in limiting the spread of communicable diseases if it were the rule in every household to isolate all children as soon as they become sick, until the nature of their illness has been determined, especially when such illness is accompanied by sore throat, running nose, or huskiness of the voice.

Diagnosis and treatment of "carriers."—When a case of diphtheria develops in a family, nose and throat cultures should be taken from the other members of the family and from those with whom the person

suffering from diphtheria has recently come in contact. In the diagnosis of "carriers" it is quite as important to take cultures from both the nose and throat as in the diagnosis of diphtheria cases. Examinations of large numbers of cultures taken from apparently healthy persons has shown that, in times of normal diphtheria prevalence, from 1 to 2 per cent of the population are "carriers" of the diphtheria germ. Further investigation has shown that in only about 1 in 10 of these "carriers" are the diphtheria germs possessed of enough strength or virulence to cause diphtheria. In carriers resulting from recent exposure to a case of diphtheria, as in the other children of a family where a case of diphtheria exists, the diphtheria germs are more likely to be virulent. In such instances the same care should be taken to prevent the spread of the germs from the "carriers" as from a case of the disease.

There can be no doubt as to the propriety of excluding children who are carriers of virulent diphtheria germs from schools or of prohibiting "carriers" who have to do with the handling of foodstuffs from engaging in their occupation until they are free from virulent diphtheria germs. In outbreaks of diphtheria in institutions "carriers" should be isolated until free from germs or until the germs present are shown to be avirulent.

All children who have been found to be carriers of diphtheria germs should be given the Shick test to determine their ability to resist the development of diphtheria, and if found susceptible they should be rendered immune by injection of the toxin-antitoxin mixture.

Protection of those exposed to diphtheria cases.—When a case of diphtheria has developed in a household, the question immediately arises as to the methods to be employed in protecting the other members of the family. Children who have been exposed to the case should be given the Shick test to determine the possibility of their developing the disease. Those who are shown by this test to be susceptible to diphtheria should be given a preventive dose of diphtheria antitoxin. The amount given should be from 500 to 1,000 units, and the injection should be made into the tissues immediately under the skin. In the case of exposed children it is often advisable to give a preventive dose of antitoxin without waiting for the results of the Shick test.

Protection of school children.—As already pointed out, we have means of preventing deaths from diphtheria after the disease has developed and a means of preventing the development of cases of diphtheria. We also have, in the Shick test, a way to determine what members of the whole population may develop diphtheria on exposure. Extensive use of the Shick test has been made in several cities of this country, notably New York, and in many institutions.

After this test has shown which children are not protected naturally against diphtheria, the toxin-antitoxin mixture is given and complete immunity conferred in almost all instances. The simplicity of the Shick test and the harmlessness of the toxin-antitoxin, together with the high degree of protection given, will appeal to many parents who have children below the school age. It is to be hoped that it will be employed in school work as extensively as has vaccination against smallpox. Considering the number of diphtheria carriers normally present in the whole population, the extensive use of toxin-antitoxin seems the only method we now have of controlling the occurrence of diphtheria.

Organization for the public control of diphtheria.—The following are necessary for the efficient public control of diphtheria:

1. A properly organized health department with a competent health officer at the head.
2. The prompt notification of all cases of diphtheria.
3. A laboratory for the bacteriological diagnosis of diphtheria.
4. A sufficient corps of public health nurses for the visiting and control of reported cases.
5. A contagious disease hospital, to which persons suffering from diphtheria can be moved, when, from an inspection of their premises, it is evident that they can not remain at home without danger to others.
6. The free distribution of antitoxin.
7. Maintenance of the quarantine of persons suffering from diphtheria until at least two successive nose and throat cultures fail to show the presence of the diphtheria germs.
8. A sufficient number of stations at convenient points at which outfits for making diphtheria cultures can be obtained.
9. An adequate system of physical supervision of school children.
10. Public spirited cooperation on the part of the health department, the medical profession, and the public.
11. Education of the public as to the use of the Shick test, and the protection conferred by the toxin-antitoxin mixture.

DEATHS DURING WEEK ENDED AUGUST 5, 1922.

Summary of information received by telegraph from industrial insurance companies for week ended August 5, 1922, and corresponding week, 1921. (From the Weekly Health Index, August 8, 1922, issued by the Bureau of the Census, Department of Commerce.)

	Week ended Aug. 5, 1922.	Corresponding week, 1921.
Policies in force	49,054,506	46,068,087
Number of death claims	7,303	7,386
Death claims per 1,000 policies in force, annual rate	7.8	8.4